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New Hampshire Coastal Zone Management Program

COASTAL ZONE

INFORMATION CENTER

NORMANDEAU ASSOCIATES INC.

a unit of Thermo Water Management Inc.

PHASE II REPORT:

TOPOGRAPHICAL SURVEY AND
HYDROLOGICAL ANALYSIS

OF THE

WALLIS SANDS AND
PHILBRICK BROOK MARSHES -

SPECIFIC RECOMMENDATIONS
FOR DRAINAGE IMPROVEMENTS

Submitted to

THE TOWN OF RYE, NEW HAMPSHIRE

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1.0 INTRODUCTION

Normandeau Associates Inc. (NAI) has completed the Topographical Survey and Hydrological Analysis of the Wallis Sands and Philbrick Brook salt marshes in the town of Rye, New Hampshire.

The objective of the current study is to provide the physical basis for tidal restoration in two of Rye's salt marshes located in the Wallis Sands and Philbrick Brook watersheds. The results are presented in three phases. Phase I is an evaluation of existing conditions in the two study areas, including hydrology, topography and engineering features, and general recommendations for achieving marsh restoration. Phase II recommends specific engineering and drainage improvements to achieve optimal tidal flushing and flood protection. Phase III assesses the impacts of drainage alterations on surrounding development, including properties, septic systems, structures, and roadways.

This report is a presentation of Phase II results, including 1) a summary of marsh hydrologic data; and 2) specific recommendations for engineering and drainage improvements.

The New Hampshire Coastal Program provided a grant for the preparation of this report, which was funded in part by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration.

2.0 HYDROLOGIC SUMMARY

Topographic and hydrologic data were integrated in Phase I to develop general recommendations for improving stormwater drainage and tidal exchange. The following section summarizes those data that were used to develop specific design recommendations for Phase II. Some of these data were included in the Phase I report, and are reiterated here for continuity. All elevations in this report refer to the National Geodetic Vertical Datum (NGVD).

Included in this section are: 1) volume estimates for all basins up to 5.0 feet NGVD; and 2) volume exchange estimates for basins with restricted flow based on tidal measurements of 16 March 1988.

2.1 BASIN VOLUME ESTIMATES

Volumes of marsh basins in the Wallis Sands and Philbrick Brook marshes are given in Table 1. These estimates are based on interpretation of 1" = 1000' aerial photography and field reconnaissance. Topographic contours were determined at 5.0-foot intervals, relative to NGVD, up to an elevation of 10.0 feet (i.e., contours were established at 0.0, 5.0, and 10.0 feet). The 5.0-foot contour approximated the transition zone from salt marsh to upland throughout the study areas, and generally corresponds to the level of spring tide flooding. Thus, the basin volume up to the 5.0-foot contour is the approximate capacity of the marsh during spring high tides which occur roughly twice per month.

Basin volume estimates were used to estimate volume exchanges (Section 2.2), and to estimate water budgets for tidally restricted basins. Water budgeting yielded information on baseline freshwater inflow and percent tidal exchange used in the placement and design of drainage improvements.

TABLE 1. VOLUME ESTIMATES FOR INDIVIDUAL BASINS OF THE WALLIS SANDS AND PHILBRICK BROOK SALT MARSHES, RYE, NEW HAMPSHIRE.

BASIN DESCRIPTION	BASIN SERVED BY CULVERT	APPROXIMATE BASIN VOLUMES (CUBIC FEET)			
		TIDAL CREEKS AND PONDS	MOSQUITO DITCHES	MARSH SURFACE	TOTAL UP TO 5.0' NGVD
WALLIS SANDS MARSH		1,043,743	45,255	3,454,609	4,543,607
South of Wallis Rd. to Washington Rd. and east of Brackett Rd. (Massacre marsh)	Concord Point Outlet	514,622	33,375	1,922,169	2,470,166
West of Brackett Rd. (upper Massacre marsh)	5	600	-	13,360	13,960
North of Wallis Rd., west of Ocean Blvd., and south of Marsh Rd.	4	427,757	11,090	1,180,953	1,619,800
East of Ocean Blvd., south of Wallis Sands beach parking.	3A & 3B	32,673	300	72,007	104,980
North of Marsh Rd., southeast of Parsons Rd.	2	68,091	490	33,801	102,382
North of Parsons Rd., east of Brackett Rd.	1	-	-	232,319	232,319
PHILBRICK BROOK MARSH					
East of Ocean Blvd. and south of Harbor Rd.	Rye Harbor Outlet	1,073,635	7,230	1,671,347	2,752,212
West of Ocean Blvd., south of Harbor Rd. to Locke Rd.	7 & 8	45,379	1,100	225,417	271,896
Southwest of Locke Rd. and west of Yushak Driveway	9	9600	3100	183,358	196,058
East of Yushak Driveway and west of Ocean Blvd.	10	26,100	430	95,629	122,159
East of Ocean Blvd. and west of Old Beach Rd.	11	-	-	72,963	72,963

Basin volumes are given in cubic feet, and may appear immense to those unaccustomed to these units. To put these figures in perspective, it is helpful to consider the sizes of the areas involved. The Wallis Sands and Philbrick Brook Study areas are approximately 185 and 100 acres in area, respectively. One acre equals 43,560 square feet, hence a foot of water covering an acre (one acre-foot) is 43,560 cubic feet in volume. One hundred acre-feet thus contains 4,356,000 cubic feet of water. By comparison, the estimated volume of water leaving Wallis Sands Marsh at Concord Point during a single ebb tide on 16 March, 1988 was 1,819,200 cubic feet.

2.2 TIDAL VOLUME EXCHANGES

Water volume exchanges were measured over a spring tidal cycle on 16 March 1988 at suspected points of restriction throughout the Wallis Sands and Philbrick Brook marshes. Points of restriction were illustrated in the Phase I report using graphs of water levels measured simultaneously on both sides of suspected pipes, culverts, sluiceways, and bridges.

For Phase II it was necessary to determine the relative severity of the restrictions revealed during Phase I. To accomplish this, volume exchange measurements made on 16 March 1988 were coupled with the basin volume estimates given in Table 1. Table 2 summarizes these data and provides estimates of percent volume exchanges.

2.3 STORM WATER RUNOFF SUMMARY

The effectiveness of existing structures for channeling stormwater runoff was evaluated for several scenarios of tidal height and magnitude of storm event, using HEC-1 stormwater modeling software (HEC-1 1985). HEC-1 evaluates stormwater runoff by estimating the peak

TABLE 2. PERCENT VOLUME EXCHANGE MEASURED IN TIDALLY RESTRICTED BASINS ON 16 MARCH 1988 IN THE WALLIS SANDS AND PHILBRICK BROOK SALT MARSHES, RYE, NEW HAMPSHIRE. FOR THESE CALCULATIONS, UPSTREAM BASINS RECEIVING TIDAL INPUT DURING SURVEY ARE ADDED TO TOTAL VOLUMES OF DOWNSTREAM BASINS.

BASIN SERVED BY CULVERT	BASIN VOLUME (CF)	VOLUME OUTPUT (CF)	TIDAL INPUT (CF)	PERCENT TIDAL EXCHANGE
WALLIS SANDS MARSH				
Culvert #1	232,319	29,760	0	0
Culvert #2	102,382	11,331	0	0
Culverts #3A and #3B	104,980	6408	6228	6
Culvert #4				
creeks only	543,827	85,184	71,179	13
creeks & surface	1,724,780	85,184	71,179	4
PHILBRICK BROOK MARSH				
Culvert #11	72,963	4892	420	0.6
Culvert #10	195,122	75,337	59,170	30
Culvert #9				
creeks only	207,822	152,298	41,999	20
creeks & surface	391,180	152,298	41,999	11

runoff for storms of various magnitudes. In addition to storm magnitude, factors must likely to affect peak runoff are the size of the watershed, predominant soil types, and degree of development (especially paving).

In Table 3, HEC-1 results are given for 10-year, 50-year, and 100-year storms, each of 24-hours duration. For each storm the estimated peak runoff (given in cubic feet per second) that can be expected to pass through each culvert is given for existing and hypothetical conditions. Existing structures are further evaluated according to the level of the tide at the time of peak runoff. Low tides mean greater marsh volume is available to store runoff, hence flooding will be less severe. Conversely, moon high tides (i.e., spring tides) fill the marshes to 5.0 feet or more. If peak runoff occurs during moon high tides, salt marsh areas are unavailable to store runoff, and local flooding results.

Hypothetical conditions include runoff estimates with the proposed modifications in place ("proposed structures"), and the scenario of "no structure". The "no structure" scenario is simply a basis for comparing existing and proposed conditions with an estimate of runoff assuming no roads, culverts, or other structures were in place (i.e., an unmodified, "natural" system).

Perhaps of greatest interest in evaluating flooding are the estimates for "high elevation" listed for both the Wallis Sands and Philbrick Brook study areas. These numbers represent flood elevations, in feet above NGVD, for points furthest inland along each marsh's drainage. This is the maximum flood elevation expected under each scenario, because drainage of runoff from inland portions of the marsh is restricted by downstream backup of flow.

TABLE 3. HEC-1 STORMWATER RUNOFF EVALUATIONS FOR SEVERAL SCENARIOS OF STORM MAGNITUDE AND TIDE LEVEL FOR THE WALLIS SANDS AND PHILBRICK BROOK SALT MARSHES, RYE, NH.

RYE MARSH EVALUATION — PEAK STORMWATER RUNOFF (CFS)

	10 YEAR, 24 HOUR STORM					50 YEAR, 24 HOUR STORM					100 YEAR, 24 HOUR STORM				
	NO STRUCTURE	EXISTING STRUCTURES		PROPOSED STRUCTURES		NO STRUCTURE	EXISTING STRUCTURES		PROPOSED STRUCTURES		NO STRUCTURE	EXISTING STRUCTURES		PROPOSED STRUCTURES	
SITE		LOW TIDE	MOON HIGH TIDE	LOW TIDE	MOON HIGH TIDE		LOW TIDE	MOON HIGH TIDE	LOW TIDE	MOON HIGH TIDE		LOW TIDE	MOON HIGH TIDE	LOW TIDE	MOON HIGH TIDE
WALLIS SANDS															
CULVERT 1	24	8	23	19	18	37	10	36	24	36	43	11	43	26	43
CULVERT 2	8	8	8	8	8	12	12	12	12	11	13	13	13	13	13
WALLIS ROAD	67	31	60	62	52	110	82	100	95	86	131	97	121	112	121
CULVERT 5	32	30	29	32	28	58	31	58	52	58	71	70	70	60	70
CONCORD PT.	126	70	60	77	75	212	121	106	132	133	251	148	131	159	177
HIGH ELEVATION (FT)		5.7	7.1	5.0	7.0		6.5	7.6	5.6	7.1		6.7	7.9	6.0	7.9
PHILBRICK BROOK															
CULVERT 11	3	2	1	3	2	4	3	2	3	2	4	3	2	3	2
CULVERT 10	12	10	10	12	11	19	17	16	17	16	21	20	19	20	19
CULVERT 9	56	44	51	50	41	97	64	34	66	67	116	99	63	77	91
CULVERT 8	56	41	33	50	39	97	60	23	66	59	116	72	36	77	74
RYE HARBOR	72	44	23	61	23	121	73	17	83	33	144	87	27	96	45
HIGH ELEVATION (FT)		5.8	8.7	4.8	7.8		6.7	8.8	5.9	8.4		8.5	8.9	7.2	8.4

In evaluating these data, it is important to recognize that the numbers represent predictions of a model, not actual measurements. Actual flood elevations may vary, especially if storm tides exceed moon tide elevations. Actual measurements of high elevations in inland areas for the 100-year storm of February 1978 were in the range of 7.3-9.9 feet NGVD (Gadoury 1979).

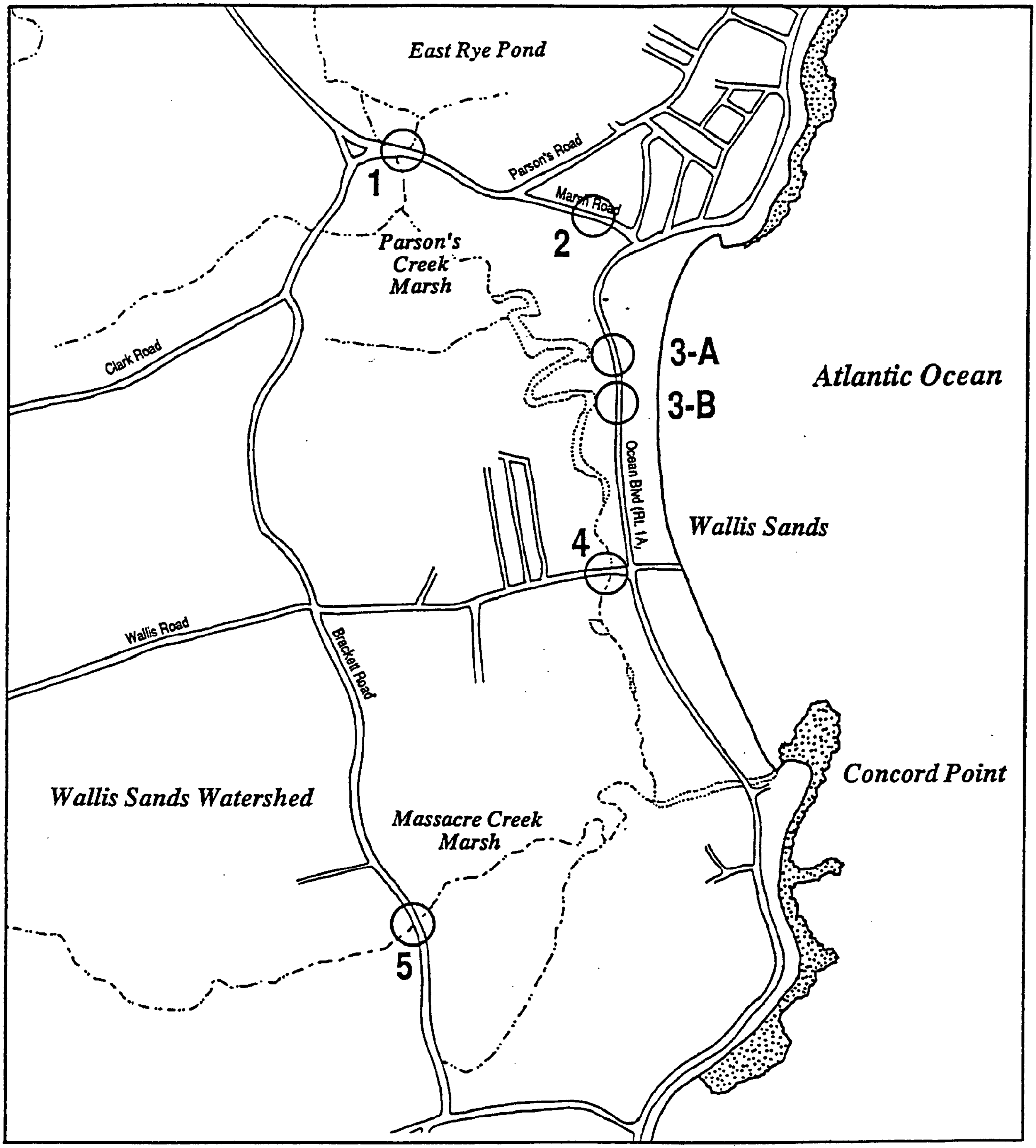
3.0 RECOMMENDATIONS

3.1 OVERVIEW

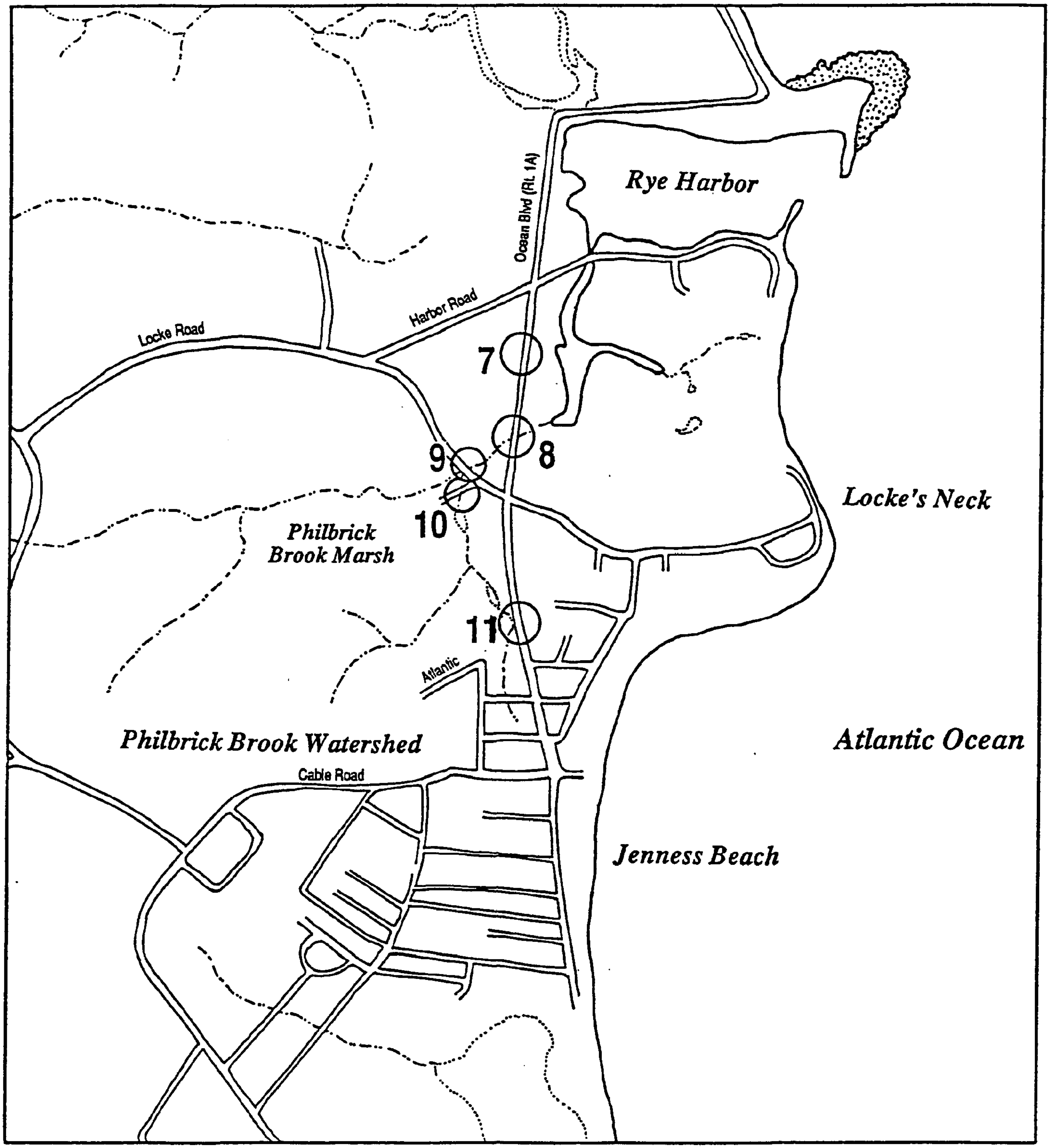
Topographic and hydrologic evaluation of the Wallis Sands and Philbrick Brook marshes has revealed four interacting factors contributing to salt marsh degradation. These are: 1) inadequate and poorly placed culverts under roads for channeling baseline freshwater flows out of marsh basins, 2) inadequate and poorly placed culverts that restrict tidal flooding, 3) clogged and inadequate tidal creeks for channeling water between culverts, and 4) man-made features on the marsh surface such as stone walls and dredge spoil that hinder surface drainage. In addition, culvert and creek inadequacies contribute to poor removal of runoff and flooding during storm events. Maps 1 and 2 show the Wallis Sands and Philbrick Brook study areas, and the locations of culverts examined in Phase I.

To develop recommendations for improvements, tidal exchange for salt marsh restoration and stormwater management were first considered separately. Improvements to meet each objective were then proposed, and integrated to develop a draft plan to meet both objectives. Finally, consideration for impacts due to coastal flooding were incorporated into the final plan presented here.

Drainage improvement recommendations are targeted toward restoring favorable conditions for the recovery and maintenance of the salt marsh community, and improving stormwater runoff through the marshes to reduce adverse impacts to roads and properties due to flooding. These objectives are generally compatible: increased pipes and channels that improve tidal flushing also provide improved stormwater management under most circumstances. Salt marsh restoration and flood protection objectives may be incompatible, however, when high tides and storm surge flood the marshes during a storm event. In such instances the storage capacity of marsh basins may be exceeded by tidal inputs.



Map 1. Wallis Sands Study Area. Points examined for tidal resrictions are circled and numbered.



Map 2. Philbrick Brook Study Area. Points examined for tidal restrictions are circled and numbered.

Additional inputs from stormwater or snowmelt may then result in serious flooding in low-lying areas. Based on records of the February 1978 storm (100-year frequency tidal flood), flooding due to storm surge may reach 10.0 ft. NGVD in areas surrounding Rye's salt marshes (Gadoury 1979). This is a foot higher than the 100-year flood level estimated for the Flood Insurance Rate Maps (FIRMs), based on 1976 data (FEMA 1986).

Absolute protection against flooding of this magnitude is not presently compatible with existing development, or the Town's objective of salt marsh restoration and maintenance. Existing development in Rye's coastal zone occurs below 10.0 ft. in many areas, most of which are subject to flood hazard under present drainage and tidal conditions. Roads built across marshes below this elevation offer little protection to landward areas because they can be over-topped by flooding. It follows that modifications of drainage structures passing under such roads cannot significantly reduce the risk of tidal flooding inland. Further, anticipated rates of sea level rise indicate a high likelihood that coastal flood hazard will increase significantly over the next 50 years (Hoffman et al. 1983). Full protection of such areas may require more sophisticated structural solutions and an active management program. These prospects are leading some coastal areas to propose development limitations in anticipation of sea level rise (LIRPB 1984). Planning is currently underway in New Hampshire to provide for flood protection and marsh preservation (Shevenell Gallen 1987, D'Agostino 1988).

Thus, a long-term plan for maintaining the Wallis Sands and Phibrick Brook salt marshes (and other salt marshes in Rye) must be but one component of a coastal management plan. This plan might consider such issues as road relocation and modification, existing and future development, and water control structures in light of the continuing rise in sea level.

Such a management plan is obviously beyond the scope of this study. However, coastal flooding and sea level rise must be considered in the course of recommending drainage improvements. To meet the objectives of this study, improvements are recommended that will:

1) improve tidal exchange to encourage marsh restoration,

2) improve stormwater removal under most circumstances, and

3) not increase, and perhaps decrease, the risk of tidal flooding during extreme events compared to existing conditions.

3.2 DRAINAGE IMPROVEMENTS

The following specific recommendations are made for improving tidal exchange and stormwater removal in the Wallis Sands and Philbrick Brook salt marshes. Place names follow Simpson (1986); and previous reports by Normandeau Associates Inc. (NAI 1986a, NAI 1986b).

Recommended improvements are given a priority rating of "H" (high), "M" (medium), and "L" (low), for each stated objective. Thus, an improvement that is critical for salt marsh restoration may have a rating of "H" for improving tidal exchange. However, its importance to stormwater runoff may be quite low and thus rate "L" for that objective. In general, improvements that will affect a large area are rated "H", while smaller-scale improvements are rated "M" or "L". Stormwater and flood protection improvements are all given high priority ratings.

General Specifications:

1) Culverts should be installed with minimal slope, not less than .002 ft/ft, positive seaward during outflow. This will encourage self-cleaning toward the seaward end during outflow.

2) All elevations are given relative to NGVD.

3) Improve and extend marsh ditches as specified following the typical section given in Figure 3. A rotary ditcher attachment, which broadcasts spoil over the marsh surface, is recommended for ditch digging.

4) Spoil material removed by means other than the rotary ditcher should be disposed of on upland areas.

5) Low ground pressure (LGP; PSI $\leq$ 2.0) equipment is recommended for any work requiring operation on the marsh surface.

6) Work requiring operation of heavy equipment on the marsh surface should be performed during October-April to avoid adverse impacts to salt marsh vegetation, peat structure, and wildlife.

7) All work in salt marsh areas should be performed in consultation with a salt marsh specialist. A minimum of three reviews are recommended: 1) review of final construction drawings, 2) review of work during construction, and 3) review following construction.

8) Self-regulating tide gates of the type designed by Nekton Associates, Inc. of Fairfield, Connecticut (Tom Steinke, Sr., President), or similar, are recommended.

WALLIS SANDS MARSH

Site: Culvert #1

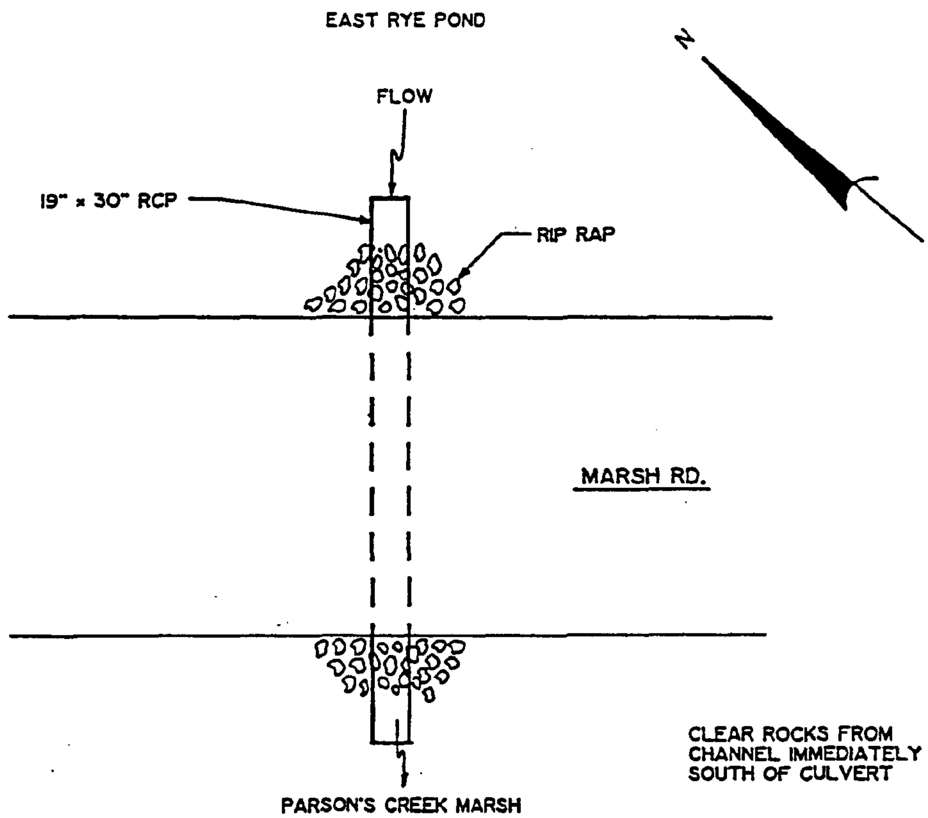
Recommendation #1: Replace existing culvert with 19" x 30" RCP set at approximately 4.0' invert elevation. Extend new pipe approximately one foot beyond existing culvert at both ends. Clear rocks from channel immediately south of culvert (Figure 1, see Map 1 for location).

Rationale: Improve stormwater runoff capacity (H). Maintain East Rye Pond as brackish pond.

Site: Culvert #2

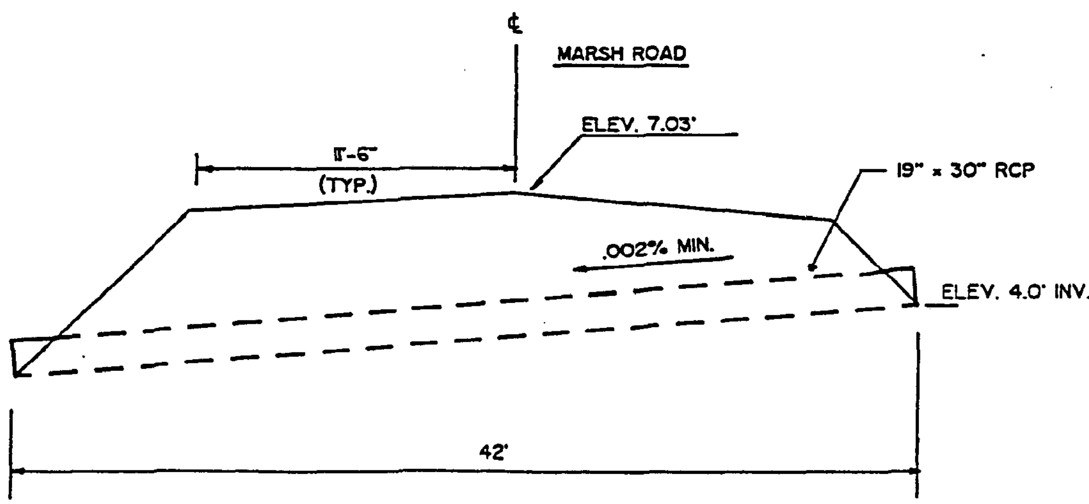
Recommendation #2: Maintain existing culvert. Extend and improve existing ditches north and south of Culvert #2 (Figure 2) such that a continuous open channel exists between Parsons Creek and the marsh basin served by Culvert #2.

Optional: Install self-regulating tide gate to protect against tidal storm surge. However, low profile of road provides only minimal protection.



PLAN

NO SCALE



PROFILE

WALLIS SANDS MARSH

CULVERT # I

NO SCALE

FIGURE 1

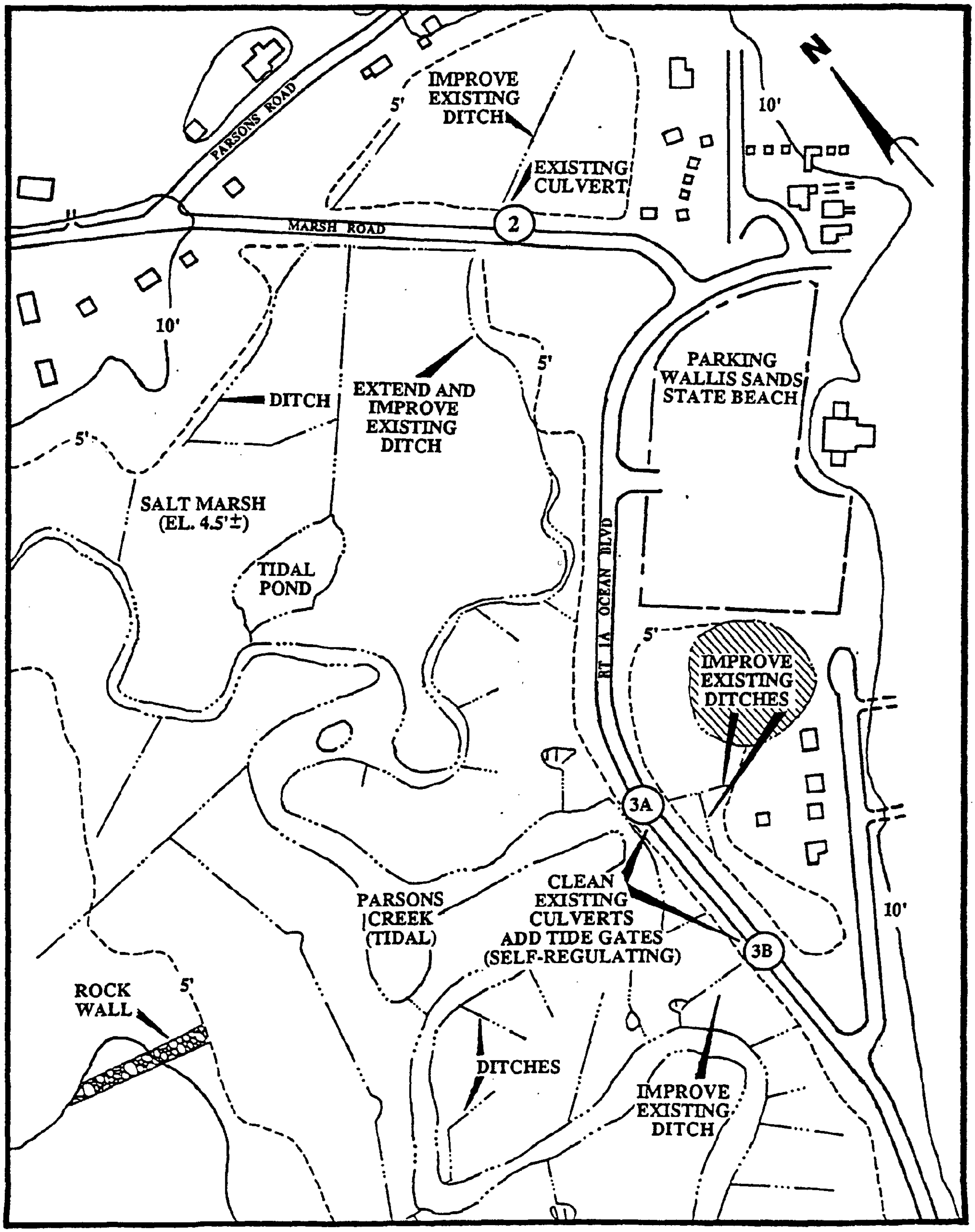


Figure 2. Recommended improvements for northern part of Wallis Sands salt marsh, Rye, NH.

Rationale: Improve tidal exchange (M). Minor protection against tidal storm surge (optional).

Site: Culvert #3A

Recommendation #3: Clean existing culvert. Improve existing ditches east of Ocean Blvd., especially the ditch extending south to Culvert #3B (Figure 2). Install self-regulating tide gate over west end of pipe.

Rationale: Improve tidal exchange (M). Protect against tidal storm surge (H).

Site: Culvert #3B

Recommendation #4: Clean existing culvert. Improve existing ditch between culvert and Parsons Creek to the west (Figure 2). Install self-regulating tide gate over west end of pipe.

Rationale: Improve tidal exchange (M). Protect against tidal storm surge.

Site: Wallis Road Vicinity (Culvert #4)

Recommendation #5: Relocate creek in vicinity of Horse Paddock and Trash Corner (Figure 5). Follow detail given in Figure 4.

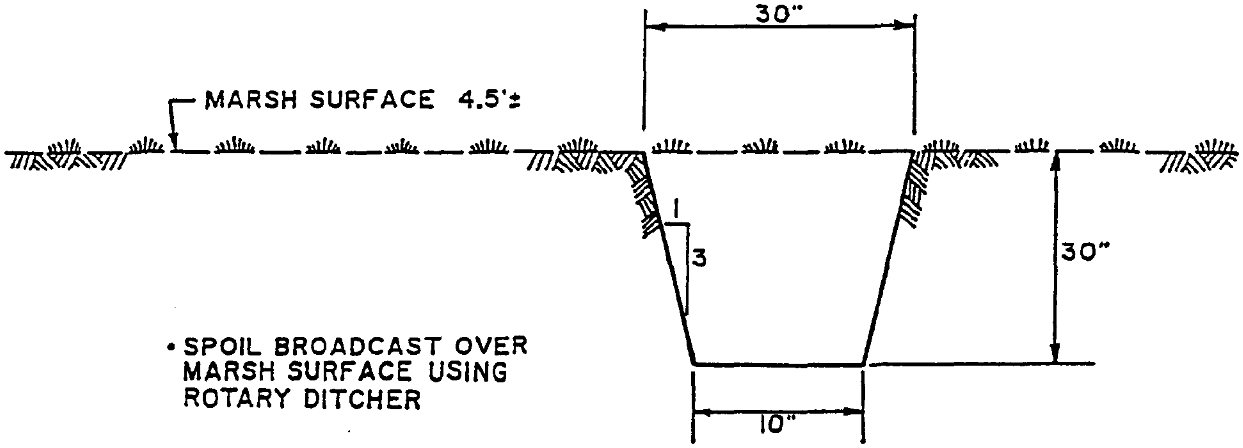
Rationale: Improve tidal exchange (H). Alleviate erosion and encroachment problems at Trash Corner (H).

Recommendation #6: Deepen existing creek in the vicinity of Wallis Road by approximately 1.0 ft., to a bottom elevation of approximately 2.5 ft. (Figure 2).

Rationale: Improve tidal exchange (H).

Recommendation #7: Remove remnant of Old Wallis Road roadbed from creek channel (Figure 5). Follow detail given in Figure 6.

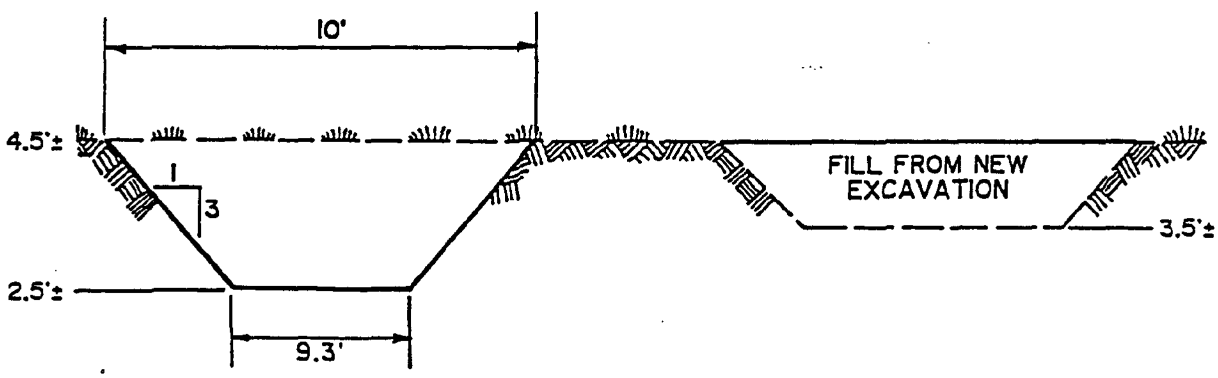
Rationale: Improve tidal exchange (H).



TYPICAL DITCH SECTION

NOT TO SCALE

FIGURE 3



SECTION E - E'

NOT TO SCALE

FIGURE 4

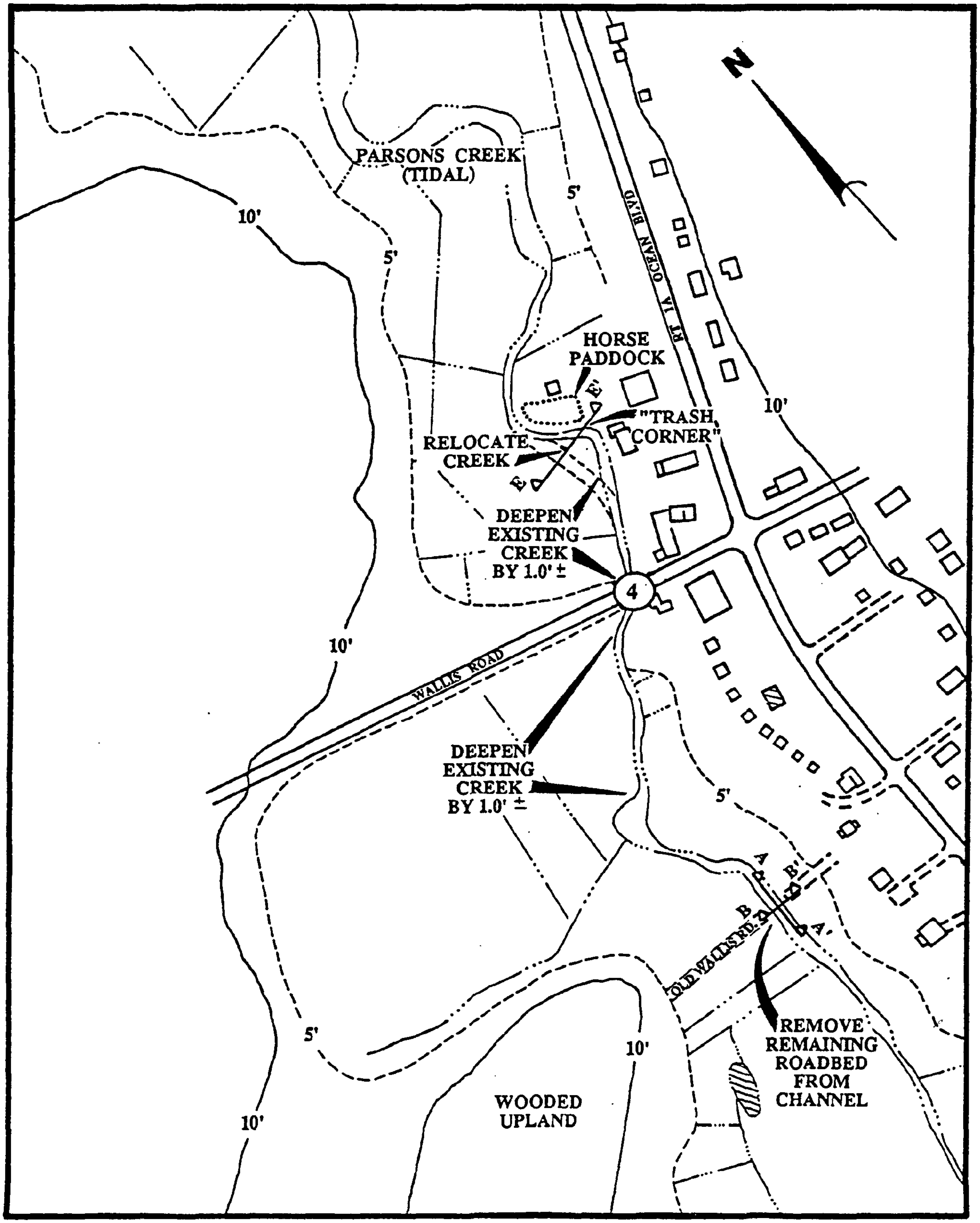
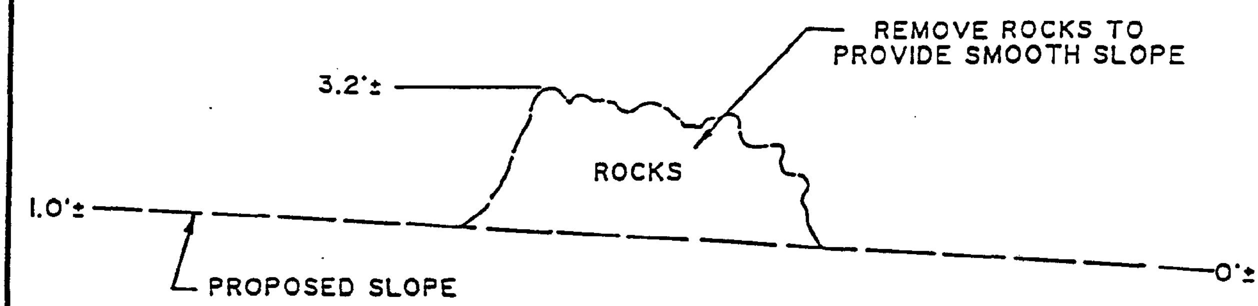
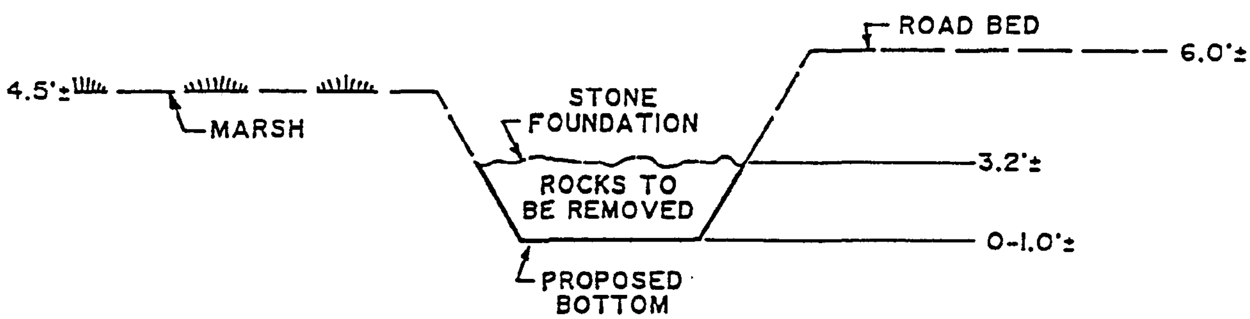


Figure 5. Recommended improvements for Wallis Sands salt marsh in the vicinity of Wallis Road, Rye, NH. See Figures 6 and 7 for section details.



OLD WALLIS ROAD ROADBED
SECTION A - A'
NOT TO SCALE



OLD WALLIS ROAD ROADBED
SECTION B - B'
NOT TO SCALE

FIGURE 6

Site: Culvert #5

Recommendation #8: Maintain existing culvert (Map 1). In the course of a routine replacement program, replace with similar capacity pipe set approximately 0.5 - 1.0 ft. below existing invert elevation of 3.5 ft.

Rationale: Improve tidal exchange (L).

Site: Concord Point Outlet (Map 1)

Recommendation #9: Maintain channel free of sediment and organic matter buildup. If possible, remove barge remnants and reconfigure channel as previously specified.

Rationale: Improve tidal exchange (H).

PHILBRICK BROOK MARSH

Site: Culvert #11

Recommendation #10: Replace culvert with 24-inch RCP set at approximately 3.5 ft. Improve and extend ditches east of the pipe (Figures 7 and 8) to create a 6-foot radius, semicircular basin at the pipe mouth, with drainage ditches extending north and south from the basin at the foot of the highway embankment.

Rationale: Improve tidal exchange (M).

Site: Culvert #10

Recommendation #11: Replace existing culvert with 29" x 45" RCP set horizontally at approximately 2.5 ft. (existing CMP is at approximately 3.0 ft.). Improve existing creek by removing sediment deposits east of pipe (Figures 7 and 9).

Rationale: Improve tidal exchange (L).

Site: Culvert #9

Recommendation #12: Replace existing culvert with 29" x 45" RCP set at approximately 2.0 ft. Improve existing creek by removing sandbar south of pipe, and rocks and peat chunks north of pipe (Figures 10 and 11).

Rationale: Improve tidal exchange (H).

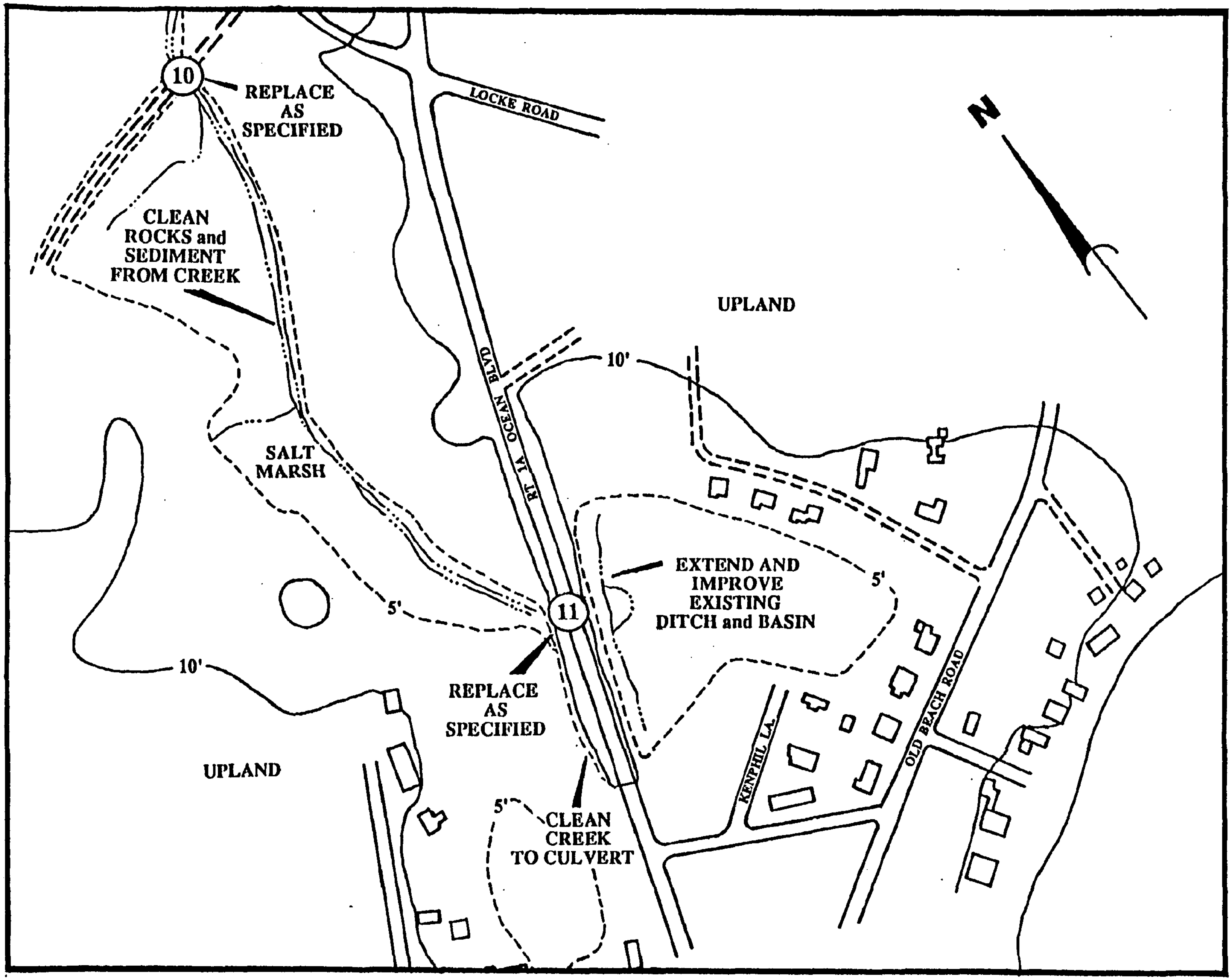
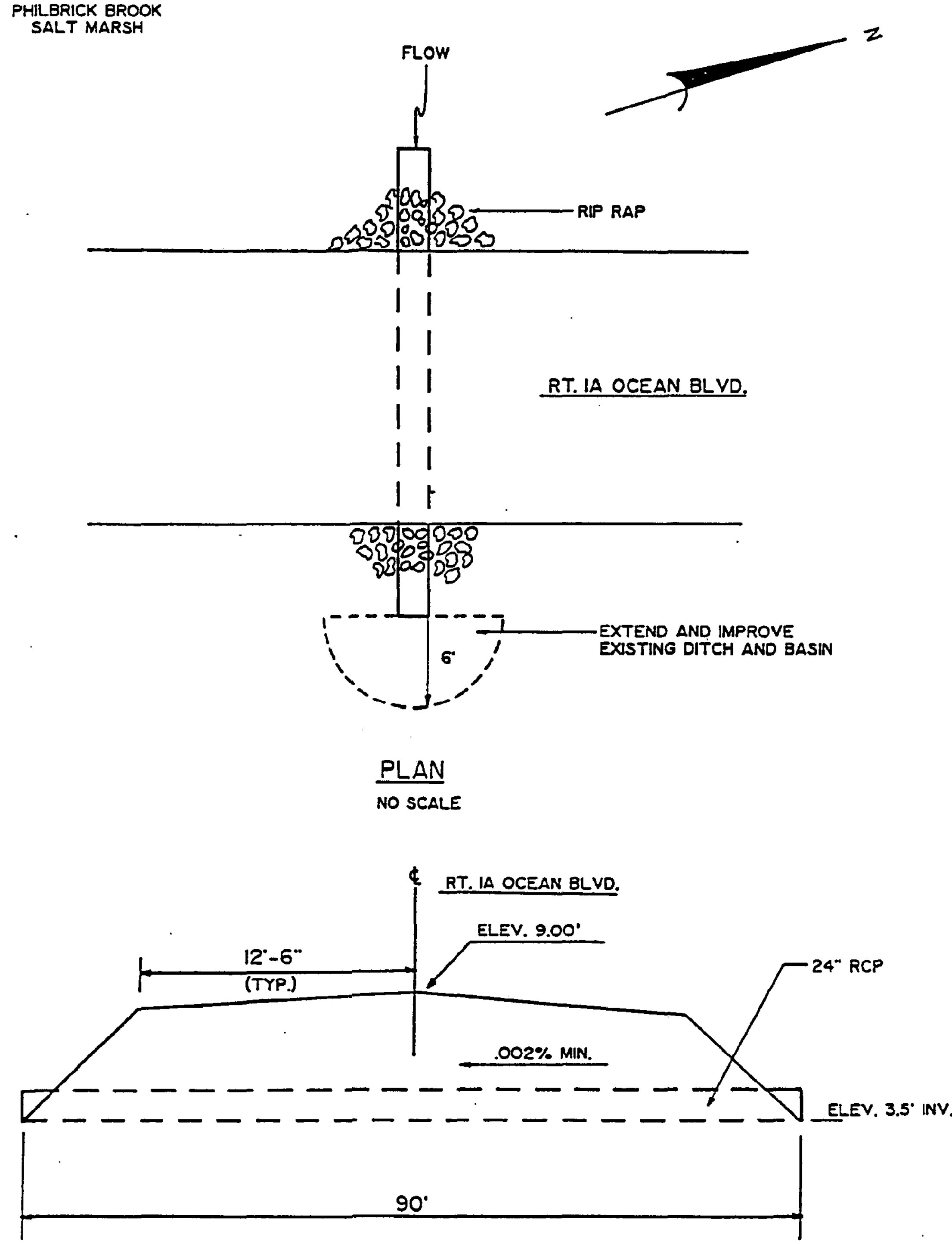


Figure 7. Recommended improvements for southern part of Philbrick Brook salt marsh, Rye, NH.



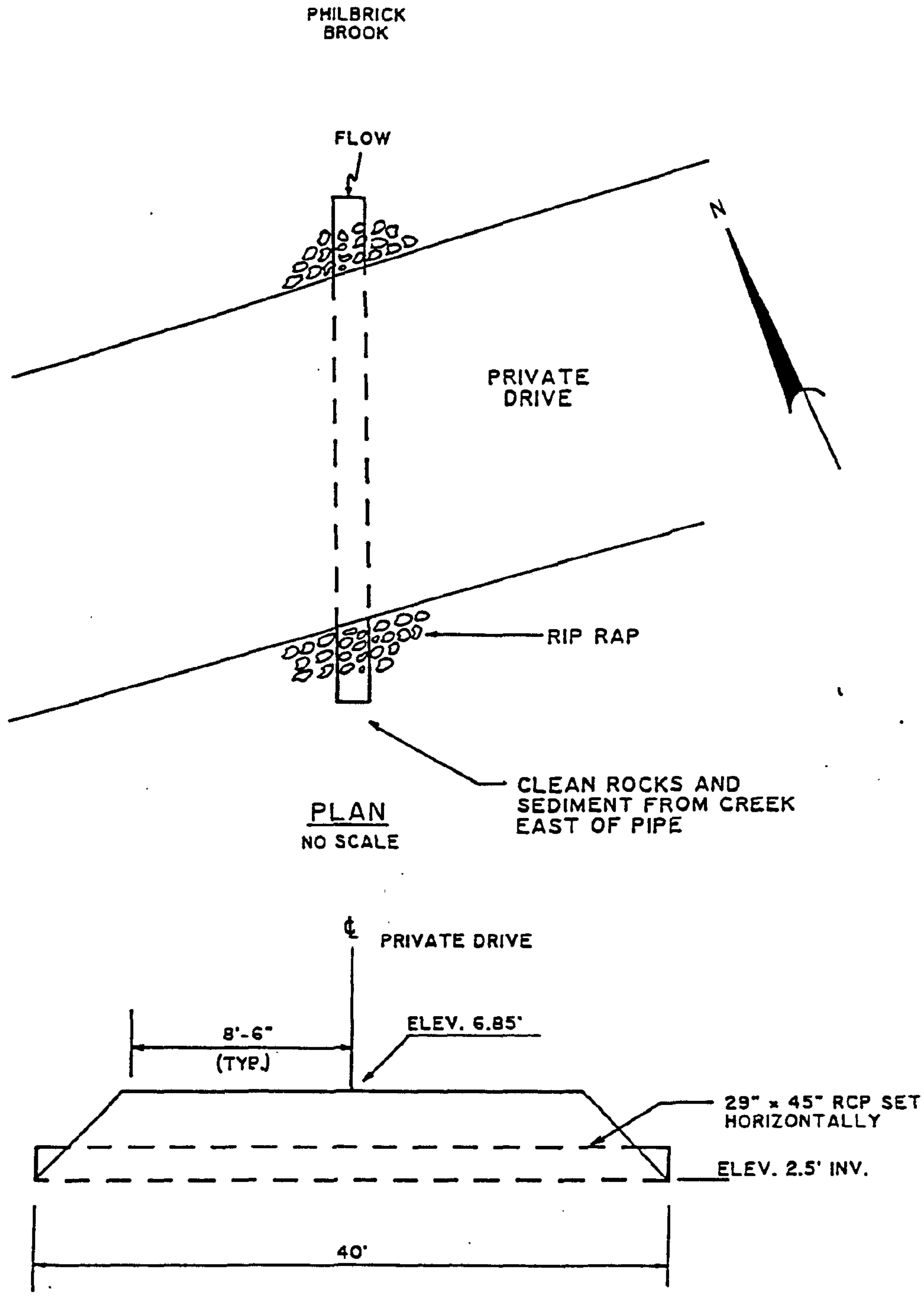
PROFILE

PHILBRICK BROOK MARSH

CULVERT # II

NO SCALE

FIGURE 8



PROFILE

PHILBRICK BROOK MARSH

CULVERT # 10

NO SCALE

FIGURE 9

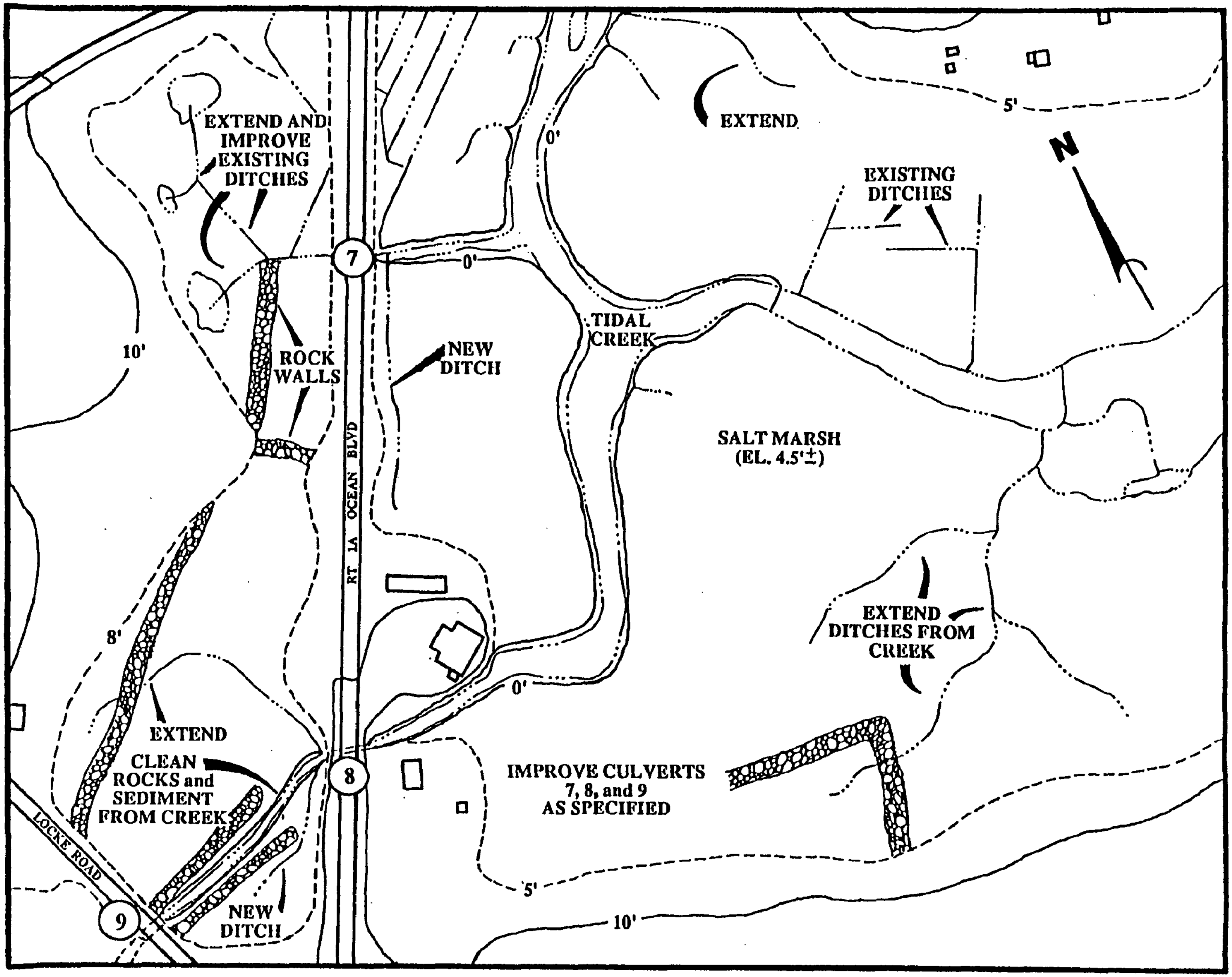
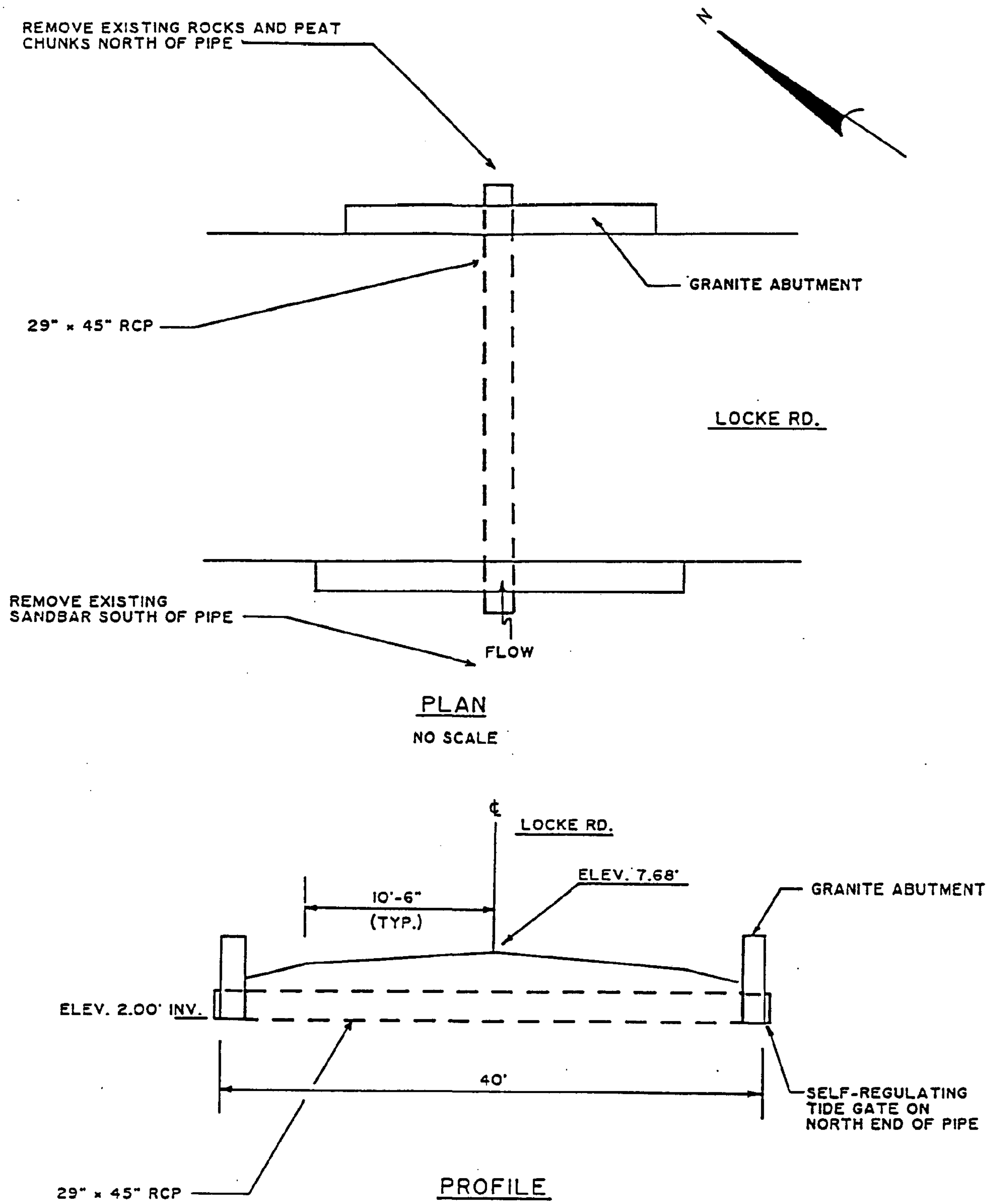


Figure 10. Recommended improvements for northern part of Philbrick Brook salt marsh, Rye, NH.



PROFILE

PHILBRICK BROOK MARSH

CULVERT # 9

NO SCALE

FIGURE 11

Site: Culvert #8 (Granite sluiceway)

Recommendation #13: Replace existing sluiceway with similar structure approximately 48 inches wide with same invert elevation. Install self-regulating tide gate at east end of sluiceway.

Rationale: Improve stormwater runoff capacity (H). Improve tidal exchange (L). Protect against tidal storm surge (H). Replace deteriorated structure.

Recommendation #14: Dig new ditch from tidal creek near west end of Culvert #8 southeast into panne area (Figure 10).

Rationale: Improve tidal exchange (L).

Recommendation #15: Improve and extend existing ditch from vicinity of west end of Culvert #8 southwest through panne areas and existing stone walls (Figure 10).

Rationale: Improve tidal exchange (M).

Site: Culvert #7

Recommendation #16: Extend and improve existing ditches west of Ocean Blvd to pass through existing rock walls and intersect panne areas (Figure 10). Install self-regulating tide gate at east end of pipe.

Rationale: Improve tidal exchange (M). Protect against tidal storm surge (H).

Recommendation #17: Dig new ditch from vicinity of east end of Culvert #7 south into panne area. Extend ditch through panne area for maximum effectiveness. Locate ditch in the marsh, as near as practicable to the base of the highway embankment (Figure 10).

Rationale: Improve tidal exchange (M).

Site: Marsh South of Rye Harbor

Recommendation #18: Extend ditches from existing creek in southern part of marsh through stone walls and into panne areas (Figure 10).

Rationale: Improve tidal exchange (M).

Recommendation #19: Extend existing ditch east of main tidal creek near Harbor Road bridge east into panne area (Figure 10).

Rationale: Improve tidal exchange (L).

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